Exploration Geophysics (1993) **24**, 303–304

Palaeomagnetism of New Zealand glacigenic deposits

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Key words: Glacial deposits, late Cenozoic, dating, New Zealand

The late Cenozoic record of glaciation of the Southern Alps is one of the most detailed in the Southern Hemisphere. Despite attempts to improve the resolution of the terrestrial record, recent research has confirmed the presence of a gap in the terrestrial record of glaciation between 2.1 Ma and 0.35 Ma which has been attributed to the combined effects of rapid uplift and erosion (Suggate 1991). In contrast, evidence from South America and Tasmania suggest that glaciers were most extensive in the Southern Hemisphere middle latitudes at about 1 Ma (Clapperton, 1991; Fitzsimons and Colhoun, 1991; Fitzsimons *et al.*, 1993). In these two locations palaeomagnetic studies have proven to be a useful means of identifying Early Pleistocene deposits on the basis of polarity of glaciolacustrine sediments. Research on similar problems in Tasmania (Pollington *et al.*, 1993) stimulated a pilot project that was designed to test the existing New Zealand stratigraphic model by examining the polarity of glaciolacustrine sediments.

Sets of specimens were collected from 16 sites that represent the six major periods of glaciation in the South Island. NRM of the specimens was measured using an ScT cryogenic magnetometer in the AGSO/ANU Black Mountain Laboratory. Representative specimens were selected from each sample site and step-wise demagnetized using an alternating field demagnetizer. On the basis of the demagnetization results (Fig.1) the remainder of the specimens from each sample site where demagnetized at one or two steps between 10 and 30 mT. Representative specimens from two sample sites were difficult to interpret so the whole set of specimens was demagnetized.

Three groups of specimens can be distinguished on the basis of demagnetization behaviour (Fig. 1). Group I sediments are distinguished by high stability magnetic remanences that decay linearly to the origin on Zijderveld diagrams and plot as tight clusters on equal area nets (Figs. 1A,1B). These sediments are the highest quality data. Group II sediments are distinguished by poorly defined characteristic magnetization mostly confined to a single quadrant of the equal area plot (Fig. 1C). Only one sample site behaves like this and although all specimens were step-wise demagnetized they may be excluded from further consideration. Group III sediments show an unstable characteristic demagnetization that does not permit an evaluation of the polarity (Fig. 1D). These results have been excluded from further analysis.

Two problems encountered in the interpretation of the results concern the tectonic deformation of sediments and the low-stability characteristic magnetization of some samples. Tectonic deformation of sediments causes a problem in interpretation because in many cases the sediments occur as isolated remnants that dip at angles up to 70°. In these circumstances it is often difficult to establish whether the deposits are the right-way-up or overturned which is critical to the interpretation of the polarity results. Mapping of the exposures and the analysis of sedimentary structures has suggested that all of the sampled sediments are the right-way-up. The reason why some sediments display a low-stability characteristic magnetization is not clear. Although some of the low-stability sediments are either highly weathered or contain a high organic content, studies of weathered and organic lacustrine sediments in Tasmania have yielded good results (Pollington *et al.*, 1993).

The test of the existing stratigraphic model has produced two interesting results. Firstly, the two Late Pliocene glaciations known from south Westland and Nelson (Suggate, 1991) have a reversed polarity as expected. However, exposures of the same stratigraphic units at different geographic locations plot in different quadrants on equal area nets. Thus there is some suggestion that the stratigraphy of some glacial formations may be more complex than previously thought. Secondly, some glacial deposits mapped as Late Pleistocene formations have a consistently reversed polarity. These results imply that the sediments were probably deposited during the Early Pleistocene or late Tertiary during the Matuyama palaeomagnetic epoch.

This investigation of the palaeomagnetism of New Zealand glacial lake sediments has shown that valuable stratigraphic information can be obtained from discontinuous terrestrial sequences. Perhaps more importantly, the study demonstrates that palaeomagnetic data, used together with other dating techniques and field mapping can generate important questions and lines of enquiry that are not obvious otherwise.

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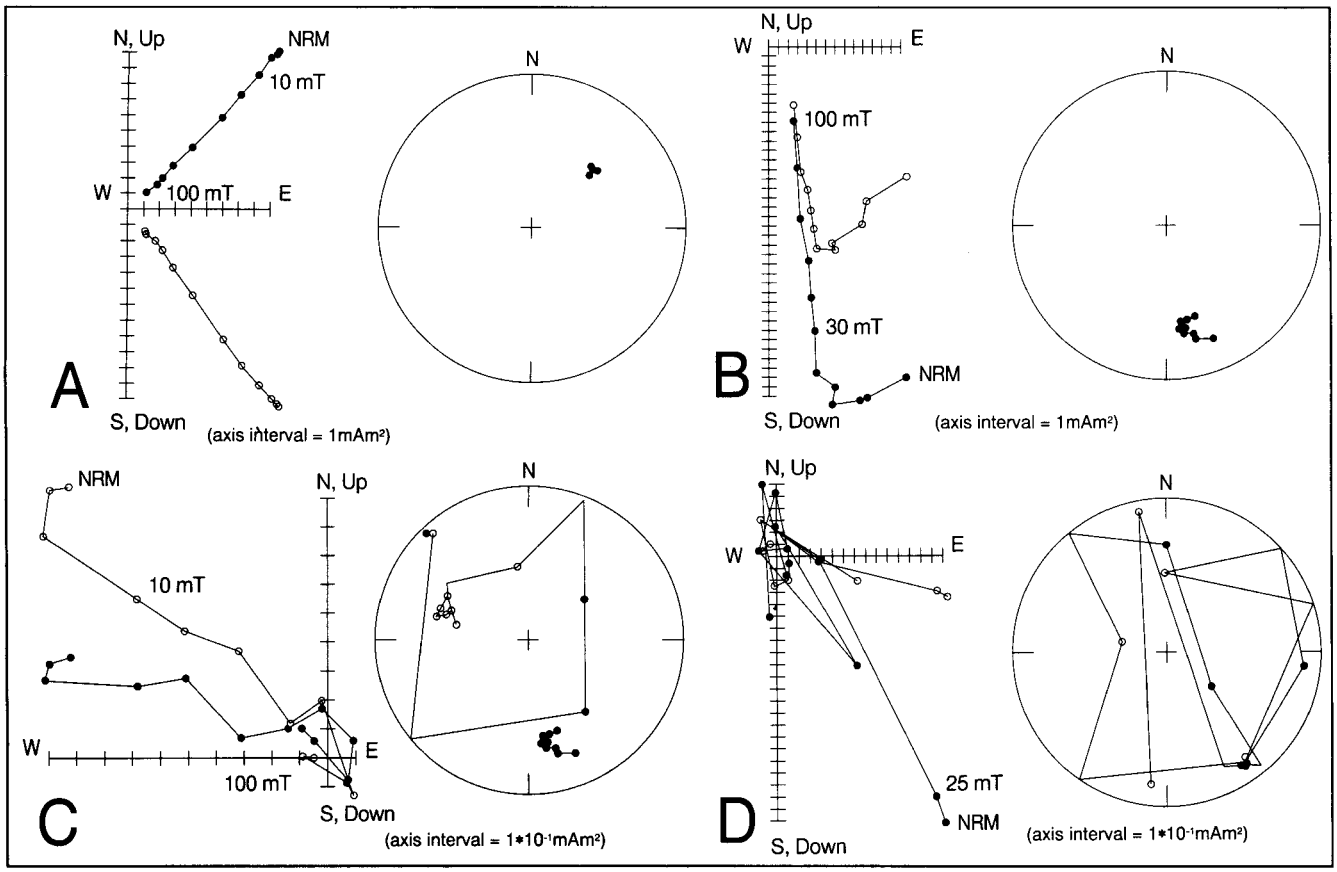

FIGURE 1
Representative Zijderveld diagrams and equal area nets showing the behaviour of speciments during demagnetisation. On the Zijderveld diagrams open circles represent projections onto the vertical plane and closed circles represent projections on the horizontal plane. On the equal area nets open circles denote normal polarity and solid circles reversed. Demagnetization of group I sediments exhibit well-defined, stable magnetic characteristics that decay linearly to the origin (A and B). Although some of the group I specimens do not have an overprint (A), most exhibit a soft overprint removed by demagnetization between 15 and 30 mT (B). Group II sediments are classified on the basis of poorly defined characteristic magnetization but the vector is mostly confined to a single quadrant on the equal area plot (C). Group III sediments show an unstable characteristic demagnetization that does not permit an evaluation of the polarity (D). Magnetizations are scaled in units of total moment for a volume of 7 cm^3.